

# New microhylid frogs from the Muller Range, Papua New Guinea

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## Abstract

We describe, from the Muller Range of New Guinea, three new species of microhylid frogs, one each in the genera *Albericus*, *Cophixalus*, and *Oreophryne*. The new *Albericus* is unique in its combination of having an infrequent peeping call, oblique lores, wide snout and finger discs, and distinct tympanum. The new *Cophixalus* is distinguished by its combination of finger discs larger than toe discs, third toe longer than fifth, distinct tympanum, curved scapular ridges, dark postocular stripe, dark W-shaped mark above the shoulders, and having a call consisting of a rapid series of 6–9 musical peeps. The *Oreophryne* is unique in its combination of having a cartilaginous connection of the procoracoid to the scapula, no webbing between the toes, fifth toe longer than third, short snout, dark face, and call consisting of an extended multi-note chuckle or cackle. Each species was either common or abundant. The new *Cophixalus* shows a predilection for caves, although it is not restricted to them. Many frogs occurring in the central highlands of New Guinea are wide-ranging across much of this high-elevational region, but others are of restricted distribution. The species described herein are likely members of the latter group, although it remains to be determined whether each will prove endemic to the Muller Range.

## Keywords

*Albericus*, *Cophixalus*, *Oreophryne*, new species, cave, New Guinea, Southern Highlands

## Introduction

The herpetofauna of the central highlands of Papua New Guinea is relatively well known due to the pioneering studies of Tyler (1961, 1962, 1963a, b, 1968), Menzies (1976, 1987, 1993, 1999), Zweifel (1958, 1962, 1972), and others. However, two semi-isolated ranges straddling the upper Strickland River at the southwestern end of the central highlands remain poorly known: the Blucher Range and the Muller Range (sometimes known as the Muller Plateau).

The Muller Range is composed largely of limestone that has heavily weathered into megadolines (James 2006) and is riddled with caves, including Atea Kanada, the largest cave complex in the Southern Hemisphere. The underlying rocks are part of thick marine sequences that began forming in the late Oligocene on a subsiding shelf at the northern edge of the Australian Craton. Subsidence stopped by the early Pliocene and was followed in the late Pliocene by uplift and erosion in association with emplacement of the Star Mountain Intrusives (Francis 1980, James 2006).

Much of the Muller Range forms a plateau at roughly 2600 m elevation, with several peaks above 3600 m, including Mt. Karoma, which at 3623 m is the highest mountain in the area. The surrounding region is mostly isolated from adjacent ranges by highland valleys at elevations of 1200–1400 m.

Only six species of amphibians and reptiles, all widespread montane forms, are currently known from the Muller Range (Smith 1980). These include two species of skinks, *Papuascincus stanleyanaus* (Boulenger) and *Lobulia elegans* (Boulenger); an unidentified snake that was seen but not captured; a hylid frog, *Litoria angiana* (Boulenger); and two species of microhylid frogs, *Callulops wilhelmanus* (Loveridge) and *Cophixalus cryptotympanum* Zweifel.

In April 2009 biologists from a joint Bishop Museum/PNG National Museum expedition spent 20 days surveying the herpetofauna at elevations of approximately 1700–2200 m in the vicinity of Mt. Itukua of the Muller Range. These collections included three new species of microhylid frogs, which we describe herein.

## Materials and methods

All measurements were made with digital calipers or an optical micrometer to the nearest 0.1 mm, with the exception that disc widths were measured to the nearest 0.01 mm. Measurements, terminology, and abbreviations follow Zweifel (1985) and Kraus and Allison (2006): body length from snout–vent (SV); tibia length from heel to outer surface of flexed knee (TL); horizontal diameter of eye (EY); distance from anterior corner of eye to center of naris (EN); internarial distance, between centers of external nares (IN); distance from anterior corner of eye to tip of snout (SN); head width at widest point, typically at the level of the tympana (HW); head length, from tip of snout to posterior margin of tympanum (HL); horizontal tympanum diameter (TY); hand length, from proximal edge of palm to tip of 3<sup>rd</sup> finger (HandL); arm length,

from elbow to tip of 3<sup>rd</sup> finger (ArmL); width of the third finger disc (3<sup>rd</sup> F); width of the fourth toe disc (4<sup>th</sup> T).

We recorded calls in the field using a Sennheiser ME66 microphone and a Marantz 660 audio recorder. Call structure was analyzed using the computer program Avisoft-SASLab Pro(v4.34), available from Avisoft Bioacoustics (<http://www.avisoft.com/>).

We confirmed by dissection generic assignment of the frogs using the presence of an eleutherognathine jaw, presence/absence of clavicles and procoracoids, origin of *M. depressor mandibulae*, and position of *M. acromiohumeralis* (Burton 1990; Burton and Zweifel 1995; Menzies and Tyler 1977; Parker 1934; Zweifel and Parker 1989). Comparisons to congeners relied on direct comparison to museum material (listed in Kraus and Allison [2005a, 2005b, 2009, in press], with additional specimens noted in Appendix) and to information from Roux (1910), Parker (1934), Zweifel (1962, 1979, 2003), Menzies (1999), Richards and Iskandar (2000), Günther et al. (2001), Hiaso (2002), Günther (2003a, b, 2006), Zweifel et al. (2003, 2005), and Richards and Oliver (2007).

Type specimens are deposited in the Bernice P. Bishop Museum, Honolulu (BPBM) and Papua New Guinea National Museum and Art Gallery, Port Moresby (PNGNM). Unless otherwise noted, all latitude and longitude coordinates use the Australian Geodetic Datum, 1966 (AGD 66).

***Albericus murritus* sp. n.**

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Fig. 1A

**Holotype.** BPBM 33657 (field tag FK 13097), collected by F. Kraus, S of Tumbutu River, Muller Range, 5.6567028°S, 142.6342342°E, 1700 m, Southern Highlands Province, Papua New Guinea, 2 April 2009.

**Paratypes (n = 31).** BPBM 33636–40, Kunida, Muller Range, 5.6431159°S, 142.6342342°E, 1700 m, 21–22 March 2009; BPBM 33641, E slope Mt. Itukua, Muller Range, 5.66954°S, 142.62334°E, 2177 m, 27 March 2009; BPBM 33642–53, Tumbutu River below Mt. Paramo, 5.6503623°S, 142.63963°E, 31 March 2009; BPBM 33654–56, same data as BPBM 33642–53 except collected 1 April 2009; BPBM 33658, PNGNM 24095–96, same data as holotype; BPBM 33659, PNGNM 24093–94, Mt. Paramo, 5.64545°S, 142.63904°E, 1777 m, 2 April 2009; BPBM 33660–63, same data as BPBM 33642–53 except collected 2 April 2009.

**Diagnosis.** A small species (adult SV = 14.6–18.3 mm) distinguished by its combination of oblique lores, distinct tympanum, relatively broad snout (IN/SV = 0.081–0.096, mean 0.086), relatively wide finger discs (3rdF/SV = 0.059–0.081), and advertisement call consisting of a single peep uttered in a continuous series.

**Comparisons with other species.** The new species differs from all congeners except *A. swanhildae* Menzies and *A. exclamitans* Kraus and Allison in having a call



**Figure 1.** Photos in life of **A** paratype of *Albericus murrutus* sp. n. (BPBM 33656) **B** paratype of *Cophixalus caverniphilus* sp. n. (BPBM 33711) **C** paratype of *Oreophryne anamiatoi* sp. n. (BPBM 33764), and **D** paratype of *Oreophryne anamiatoi* sp. n. (BPBM 33765).

consisting of a peep; all other *Albericus* have calls consisting of a single honk/buzz or a series of clicks. From *A. swanhildae* the new species differs in its larger size (SV = 13.6–15.4 mm in *A. swanhildae*), oblique (vs. vertical) lores, wider finger discs (3rdF/SV = 0.055–0.061 in *A. swanhildae*), and in having a single broad dark band across the center of each shank (vs. three narrow dark bars across each shank in *A. swanhildae*). From *A. exclamitans* the new species differs in having the tympanum evident (vs. hidden) in males and in having the call consist of an infrequently produced single peep (vs. rapid burst of 3–48 peeps in *A. exclamitans*). *Albericus murrutus* is also slightly smaller than *A. exclamitans* (male SV = 14.6–18.3 mm, female SV = 15.0–18.3 mm in *A. murrutus* vs. 15.3–20.7 and 18.0–22.0 in *A. exclamitans*) and has a somewhat broader snout (IN/SV = 0.074–0.085, mean 0.079 in *A. exclamitans*).

**Description of holotype.** Adult male. Head relatively wide (HW/SV = 0.38), with oblique and shallowly concave loreal region; canthus rostralis broadly rounded; nostrils small, crescent-shaped, much closer to tip of snout than to eyes; distance from external naris to eye larger than internarial distance (EN/IN = 1.14, IN/SV = 0.083, EN/SV = 0.095); snout bluntly rounded when viewed from above, truncate when viewed from side; eyes moderately large (EY/SV = 0.13), eyelid approximately 2/3 width of interorbital distance; tympanum indistinct, partially hidden by surrounding skin. Dorsum pustulose on body and limbs; supratympanic fold absent

but row of dorsal pustules occupy that area; ventral surfaces coarsely granular. Fingers unwebbed, bearing discs with terminal grooves; relative lengths  $3 > 4 > 2 > 1$ . Finger discs approximately twice widths of penultimate phalanges. Subarticular tubercles not well developed; metacarpal tubercles absent. Toes unwebbed, bearing discs with terminal grooves; relative lengths  $4 > 5 > 3 > 2 > 1$ . Toe discs smaller than those of fingers ( $3rdF/4thT = 1.24$ ), approximately 1.5 times width of penultimate phalanges. Subarticular tubercles low; metatarsal tubercles lacking. Hind legs rather short ( $TL/SV = 0.40$ ); arms rather long ( $ArmL/SV = 0.54$ ).

In preservative, dorsal ground color an irregular mix of yellow-tan and brown, with the former predominating dorsolaterally and the latter mid-dorsally; parts of both fields suffused with russet. Irregular black flecks and markings scattered throughout, concentrated above shoulders, on rear of head, and above tympana. Traces of a short, lighter, yellow-brown bar on each scapula; similar-colored interocular bar and vestiges of lumbar ocelli. Sides dark gray flecked with black and light blue-gray. Face yellow-tan flecked with black and russet. Legs yellow-tan with one broad, dark, centrally placed band on each thigh and shank. Rear of thighs dark brown with narrow yellow-tan band proximally. Venter dirty light gray evenly and densely peppered with dark gray; palmar and plantar surfaces same. Front margin of mandible russet. Iris black flecked with silver.

**Variation.** Mensural variation for the type series is shown in Table 1. There is no obvious sexual dimorphism in morphometric features, although there is slight evidence that females may average larger in body size. However, this difference is slight considering the normal pattern of larger female size in most Papuan frogs.

Most specimens appear dark brown in preservative (darker than the holotype), with a few contrasting light-brown streaks or lines scattered on dorsum. These typically involve a single short line on each scapula, an interocular bar, and often traces of lumbar ocelli. Lighter specimens are similar but show more clearly the variable mottling seen in the holotype. Density of dark ventral stippling varies from sparse to dense, making the overall appearance of the venter vary from light gray to black. Both ventral extremes appear in frogs with both light and dark dorsa, but venters of frogs that are lighter dorsally average somewhat paler than those of dark frogs.

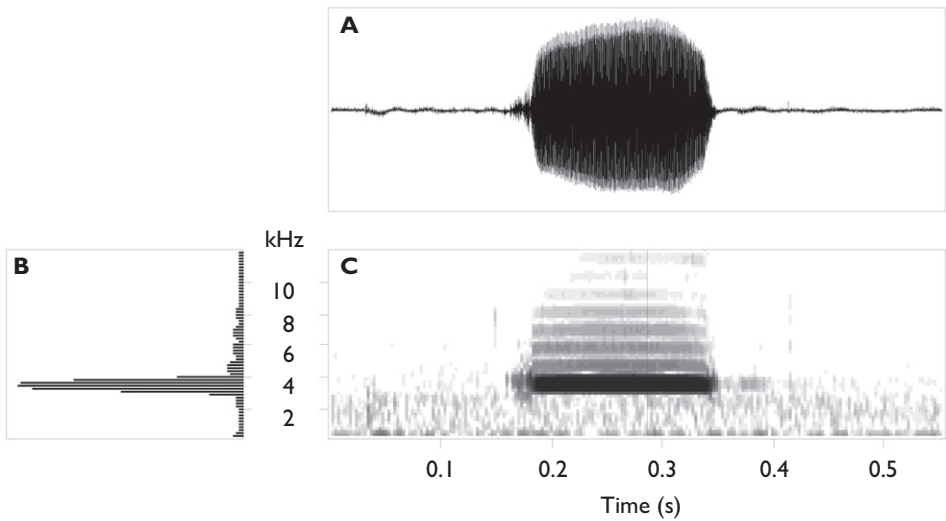
**Color in life.** BPBM 33636: "Dorsum dark tan with irregular black blotches and tiny white or tan dots on some warts; fairly warty. Orange-brown interocular bar, supra-scapular marks, and on arms and heels. Venter charcoal gray with tiny light-gray punctations. Light-tan patch from eye to rictus. Iris brown." BPBM 33637 was yellow-brown with cream and black markings, venter densely punctated with light gray, and iris tan.

**Call.** This species begins calling at dusk and calls in highest numbers during the first few hours of darkness. The call consists of a single "peep" note uttered in a continuous series with occasional breaks (Fig 2). We recorded calls of two individuals, BPBM 33641 and BPBM 33657 (Table 2). The notes had a mean duration of 0.151 s (range 0.093–0.213). The inter-note interval for BPBM 33641 ranged from 4.1–9.0 s ( $n = 20$ ), except for two instances of 31.6 and 35.9 s. Many species of *Albericus* produce calls in groups separated by periods of silence (A. Allison, pers. obs.), and our brief recording suggests that this is occurring in BPBM 33641.



**Table 1.** Mensural data for type series of *Albericus murrinus* sp. n. Data include only adult animals.

Character	Males (n = 17)		Females (n = 6)	
	Mean	range	mean	range
SV (mm)	16.6	14.6–18.3	17.2	15.0–18.3
TL/SV	0.40	0.37–0.44	0.42	0.37–0.45
EN/SV	0.097	0.089–0.106	0.098	0.093–0.107
IN/SV	0.086	0.081–0.096	0.087	0.081–0.093
SN/SV	0.15	0.14–0.16	0.15	0.15–0.16
TY/SV	0.057	0.051–0.065	0.064	0.060–0.068
EY/SV	0.12	0.11–0.13	0.13	0.12–0.13
HW/SV	0.38	0.36–0.40	0.39	0.38–0.39
HL/SV	0.32	0.29–0.35	0.33	0.32–0.34
HandL/SV	0.28	0.25–0.30	0.28	0.27–0.30
ArmL/SV	0.54	0.51–0.58	0.56	0.52–0.59
3rdF/SV	0.068	0.059–0.080	0.074	0.067–0.081
4thT/SV	0.054	0.047–0.062	0.059	0.054–0.064
EN/IN	1.14	1.06–1.23	1.14	1.07–1.21
3rd F/4th T	1.26	1.06–1.58	1.26	1.14–1.32
HL/HW	0.85	0.81–0.90	0.85	0.82–0.89



**Figure 2.** **A** Waveform, **B** power spectrum, and **C** spectrogram of call “T” of *Albericus murrinus* sp. n. (BPBM 33641) recorded on E slope Mt. Itukua, Muller Range, Southern Highlands Province, Papua New Guinea on 27 March 2009 at 2020 h. Air temperature 14.7 °C.

The call of BPBM 33657 was similar. The interval between the 36 notes in our recorded sequence ranged from 2.7–6.5 s, except in four instances that ranged in duration from 11.4–57.8 s. Again, the interval sequence suggests that the calls are produced in groups separated by periods of silence (Fig. 3).

**Table 2.** Call statistics of *Albericus murritus* sp. n. recorded by Fred Kraus on E slope Mt. Itukua, Muller Range, Southern Highlands Province, Papua New Guinea. BPBM 33641 was recorded on 27 March 2009 at 2020 h, BPBM 33657 on 2 April 2009 at 2215 h. Air temperatures were 14.7 and 18.8 °C, respectively.

Specimen	Number	Note duration (s)		Internote duration (s)		Dominant frequency (Hz)	
		Mean	Range	Mean	Range	Mean	Range
BPBM 33641	20	0.1720	0.1119–0.2126	8.5395	4.1081–35.8882	3460	3420–3510
BPBM 33657	36	0.1393	0.0934–0.1811	6.4229	2.7302–57.7857	3560	3180–3650

The call note is unpulsed (Fig. 2A) and finely tuned, with a mean dominant frequency of 3520 Hz (range 3180–3650) and a well-developed harmonic structure (Fig. 2B–C).

**Etymology.** The name is a masculine Latin adjective meaning “to squeak like a mouse”.

**Range.** Known only from the vicinity of the type locality on the northeastern slopes of the Muller Range, Southern Highlands Province, Papua New Guinea (Fig. 4).

**Ecological notes.** Animals were found while calling perched in exposed locations on leaves or twigs of vegetation 1–3 m above the ground. They inhabited primary and secondary rainforest ranging from 1700–2180 m elevation, as well as cleared areas around villages. Syntopic microhylids include *Albericus darlingtoni* (Loveridge), *Callulops wilhelmanus*, *Choerophryne burtoni* Richards, Dahl, and Hiaso, *Hylophorbus richardsi* Günther, *Oreophryne notata* Zweifel, *Xenorhina parkerorum* Zweifel, and the two species described below.

### *Cophixalus caverniphilus* sp. n.

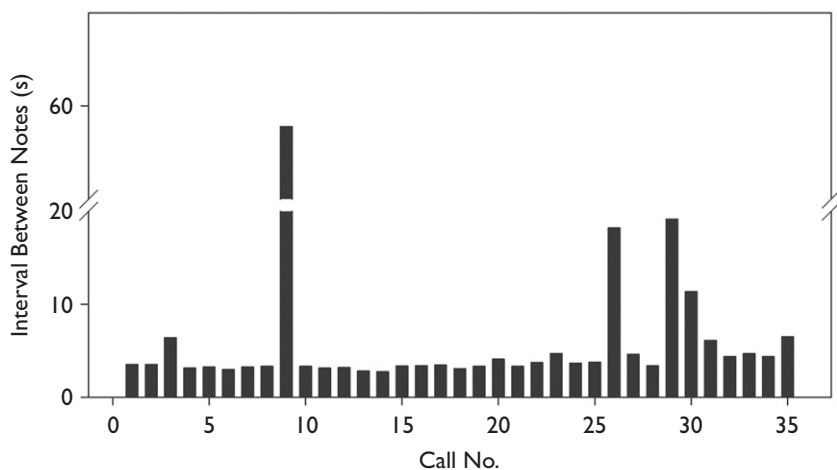
urn:lsid:zoobank.org:act:90795C42-34A3-4D52-B299-4025E0389CA3

Fig. 1B

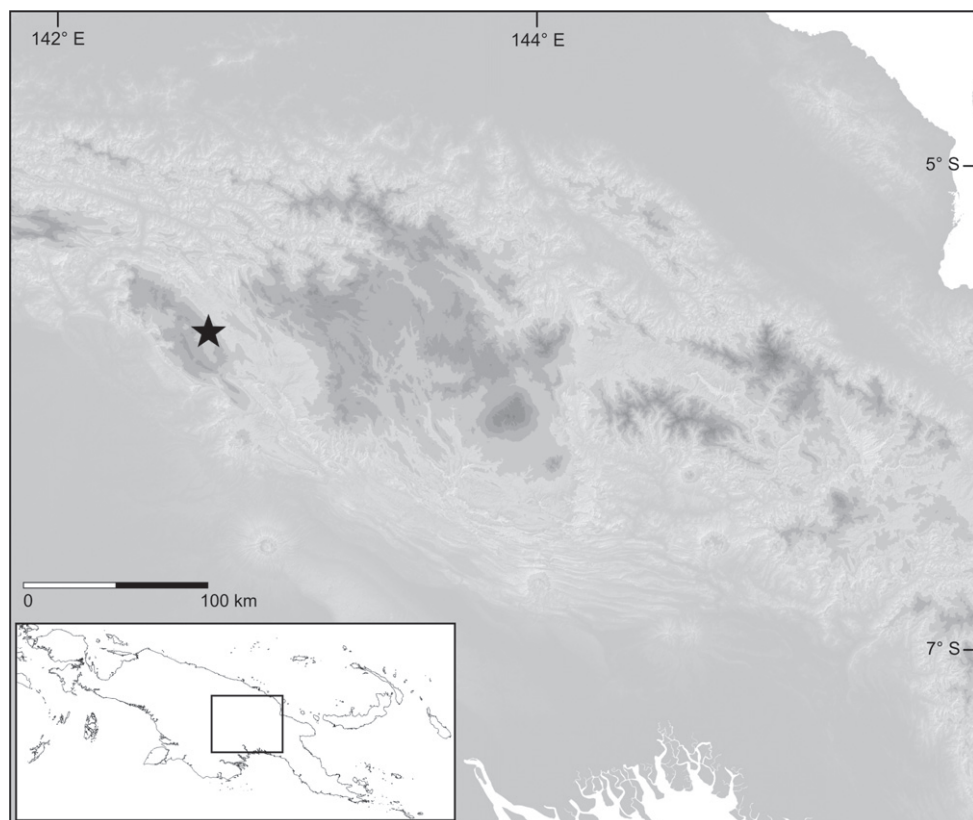
**Holotype.** BPBM 33748 (field tag FK 13180), collected by F. Kraus and D. Gibson, Mt. Paramo, Muller Range, 5.64728°S, 142.63941°E, 1718 m, Southern Highlands Province, Papua New Guinea, 5 April 2009.

**Paratypes (n = 48).** BPBM 33707, E slope Mt. Itukua, Muller Range, 5.66954°S, 142.62334°E, 2177 m, 20 March 2009; BPBM 33708–40, PNGNM 24101–07, Mt. Paramo, Muller Range, 5.64791°S, 142.63663°E, 1780 m, 22 March 2009; BPBM 33741–43, Kunida, 5.64°S, 142.63°E, 1700–1800 m, 23 March 2009; BPBM 33744–46, same data as BPBM 33707, except collected 30 March 2009; BPBM 33747, same data as holotype except collected 4 April 2009.

**Diagnosis.** A moderately large species of *Cophixalus* (adult SV = 25.5–36.7 mm) distinguished by its combination of expanded finger discs larger than toe discs (3rdF/SV = 0.069–0.107, 3rdF/4thT = 1.27–1.70); long legs (TL/SV = 0.50–0.59); third toe distinctly longer than fifth; distinct tympanum; curved scapular ridges; pustulose skin; short, dark postocular stripe; dark W-shaped mark above the shoulders; lacking a dark



**Figure 3.** Duration of the interval between call notes in the complete recorded sequence of *Albericus murrinus* sp. n. (BPBM 33657) recorded at Mt. Paramo, Muller Range, Southern Highlands Province, Papua New Guinea on 2 April 2009 at 2215 h. Air temperature 18.8 °C.



**Figure 4.** Map showing known distribution of three new species of microhylid frogs from along the eastern slope of Mt. Itukua, Muller Range, Southern Highlands Province, Papua New Guinea (star).



face and yellow spotting on the rear of thighs; and having a call consisting of a rapid series of 6–9 musical peeps.

**Comparisons with other species.** The new species differs from all congeners except *C. balbus* Günther, *C. biroi* (Méhely), *C. cheesmanae* Parker, *C. cryptotympanum*, *C. nubicola* Zweifel, *C. riparius* Zweifel, and *C. verrucosus* (Boulenger) in its combination of SV > 25 mm, finger discs larger than toe discs, and third toe longer than fifth. It differs from *C. balbus* and *C. biroi* in having (vs. lacking) raised scapular ridges, lacking (vs. having) a triangle of pale coloration on the top of the snout, having a call consisting of only 6–9 peeps (vs. long trains of peeps), and from *C. biroi* in having (vs. lacking) a dark W-shaped mark above the shoulders; from *C. cheesmanae* in having pustulose (vs. smooth) skin and in lacking the dorsolateral ridge and uniformly dark face of that species; from *C. cryptotympanum* in having an exposed (vs. obscure or hidden) tympanum, pustulose (vs. smooth) skin, a dark (vs. light) postocular stripe, and a dark W-shaped mark above the shoulders (absent in *C. cryptotympanum*); from *C. nubicola* in its longer legs (TL/SV = 0.35–0.38 in *C. nubicola*), thighs same color as (vs. conspicuously paler than) dorsum, and dorsum yellow or greenish-yellow with a dark W-shaped mark above the shoulders (vs. reddish-brown with light spots in *C. nubicola*); from *C. riparius* in its smaller size (SV = 40–50 mm in *C. riparius*) and dorsum yellow or greenish-yellow with a dark W-shaped mark above the shoulders (vs. brown with two elongated and irregular dark dorsolateral patches or network in *C. riparius*); and from *C. verrucosus* in having larger finger discs (3rdF/SV = 0.052–0.073, 3rdF/4thT = 0.96–1.26), a dark W-shaped mark above the shoulders (absent in *C. verrucosus*), and rear of thighs yellow dusted with brown (vs. spotted with yellow on dark brown in *C. verrucosus*).

**Description of holotype.** Adult male with small lateral incision on right side. Head moderately wide (HW/SV = 0.39), with steep, almost vertical, loreal region and slightly inflated lip; canthus rostralis rounded, straight when viewed from above; nostrils directed laterally, much closer to tip of snout than to eyes; internarial distance larger than distance from naris to eye (EN/IN = 0.83, IN/SV = 0.106, EN/SV = 0.088); snout rounded and somewhat projecting when viewed from the side, broadly angulate when viewed from above; eyes moderately large (EY/SV = 0.12); eyelid approximately 2/3 width of interorbital distance; tympanum indistinct and small (TY/SV = 0.049), with a slightly raised annulus anteriorly but covered by ridge of skin dorsally and posteriorly. Skin pustulose dorsally and laterally, with prominent pair of scapular ridges, granulose ventrally. Supratympanic fold present, distinct ventrally but merging with pustulose skin dorsally. Fingers unwebbed, bearing discs with terminal grooves; relative lengths 3>4>2>1; first finger and disc well-developed. Finger discs approximately 3 times widths of penultimate phalanges, except for the first finger disc, which is approximately 2 times width of penultimate phalanx. Subarticular tubercles low; inner metacarpal tubercle weakly developed, outer absent. Toes unwebbed, bearing discs with terminal grooves; relative lengths 4>3>5>2>1. Toe discs smaller than those of fingers (3rdF/4thT = 1.33); approximately twice widths of penultimate phalanges. Subarticular tubercles weakly developed; inner metatarsal

tubercle narrow, elongate, and low; outer lacking. Hind legs moderately long (TL/SV = 0.54).

In preservative, dorsum brown with broken, dark-brown scapular W, and indistinct dark-brown markings scattered throughout. Dark-brown interocular bar, postocular stripe, and loreal stripe. Face light brown with small dark-brown flecks and smudges. Rear of thighs pale straw suffused with brown stippling and having dark-brown blotching distally. Ventral surfaces pale straw yellow heavily stippled with black, this more evenly distributed on chin and throat, and more broken on abdomen and under legs. Few white flecks along margin of mandible and sparsely scattered on throat and chest. Palmar and plantar surfaces brown, latter darker. Iris very dark brown, densely flecked with brass.

**Variation.** Mensural variation for the type series is shown in Table 3. Sexual dimorphism is slight except that females are of larger size than males. There is relatively little variation in dorsal color pattern. Most specimens are similar to the holotype, but four or five have a slightly lighter ground color, and four are darker; all have the scapular W. Similarly, ventral color pattern varies little. Most specimens are like the holotype, but a few (7 or 8) have darker stippling, which gives a higher contrast to the ventral pattern.

**Color in life.** BPBM 33708: “Mustard yellow with irregular dark-brown markings; dark-brown suprascapular W and dorsolateral lines which are ridges. Iris bronze punctated with brown. Venter yellow with blue-white punctations.” BPBM 33728 was mustard yellow with black spots dorsally. The yellow color was prominent in all specimens collected.

**Call.** We heard this species call only in the morning between 0500–0930 h. We obtained good recordings of 16 calls produced by two individuals, BPBM 33747 and 33748 (Table 4). Both calls were similar, so we combined data for analysis. The call

**Table 3.** Mensural data for type series of *Cophixalus caverniphilus* sp. n. Data include only adult animals.

Character	Males (n = 17)		Females (n = 22)	
	Mean	range	mean	range
SV (mm)	28.1	25.5–30.2	33.2	29.7–36.7
TL/SV	0.53	0.50–0.57	0.52	0.50–0.57
EN/SV	0.087	0.080–0.096	0.086	0.079–0.093
IN/SV	0.101	0.096–0.106	0.098	0.090–0.103
SN/SV	0.15	0.14–0.16	0.14	0.13–0.15
TY/SV	0.045	0.038–0.051	0.050	0.043–0.060
EY/SV	0.13	0.12–0.15	0.13	0.11–0.15
HW/SV	0.38	0.36–0.40	0.37	0.36–0.40
HL/SV	0.33	0.32–0.35	0.33	0.31–0.35
3rdF/SV	0.085	0.073–0.097	0.093	0.075–0.107
4thT/SV	0.059	0.051–0.069	0.063	0.055–0.072
EN/IN	0.86	0.81–0.93	0.88	0.82–0.97
3rd F/4th T	1.44	1.33–1.66	1.49	1.33–1.70
HL/HW	0.87	0.83–0.92	0.88	0.85–0.94

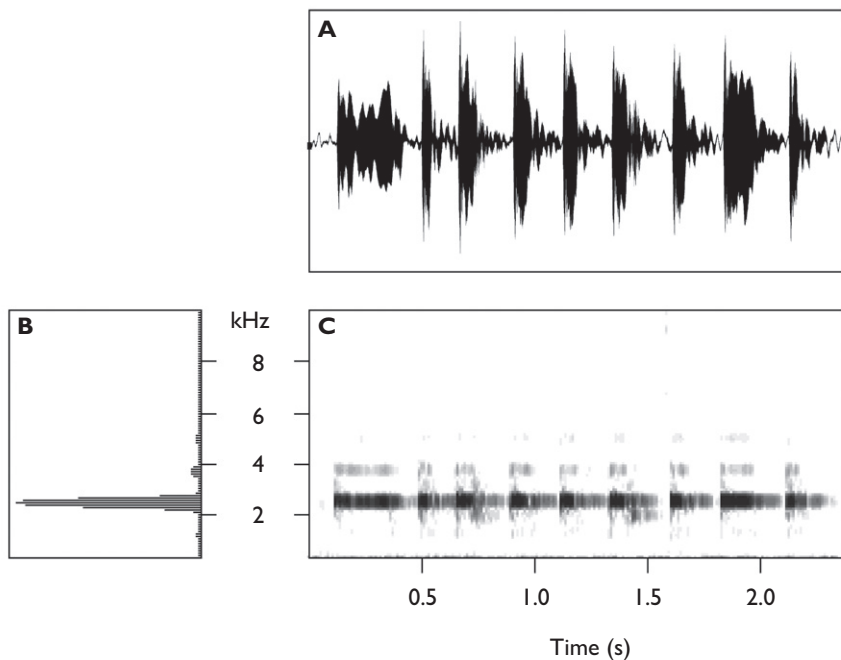
consists of 5–9 (mode = 7) regularly spaced notes delivered at a mean rate of 6.63 notes/s (range 5.65–7.57) with the acoustic impression of bell-like peeping. The mean duration of calls was 1.77 s (range 1.50–2.18). The first note, with one exception, was the longest note in the call, averaging 0.2933 s (range 0.0920–0.3280) (Fig. 5A). If the exception is excluded, the mean duration of the first note increases to 0.3067 (range 0.2818–0.3280). This note also generally had a lower amplitude than that of subsequent notes.

The second note tended to be the second longest in the call, averaging 0.1556 s (range 0.0790–0.1990). Subsequent notes were generally similar, averaging 0.1324 s in duration (range 0.0602–0.1960), but in nine of the 16 calls the last note was the shortest in the call, with a duration ranging from 0.0602–0.1100 s.

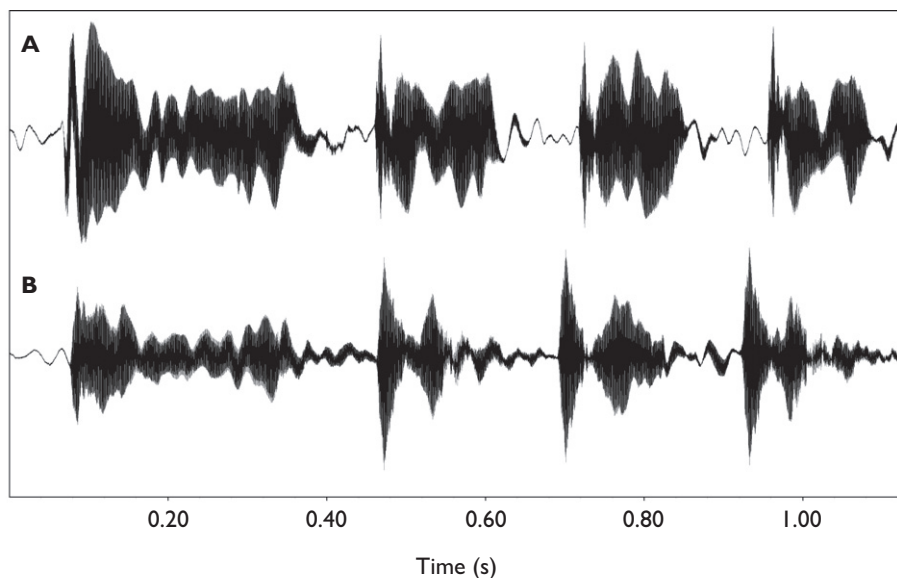
There was a slight tendency for pulsing of the first note (Fig. 6A–B). This is more apparent in the second and subsequent notes, particularly in BPBM 33748 (Fig. 6B), in which the first note generally included upwards of 8–9 irregular, often partial pulses. Subsequent notes, particularly in BPBM 33748, generally had at least two components: a short, high-amplitude pulse of ~0.03–0.04 s followed by a longer, lower-amplitude pulse that was generally 0.07 s or more in duration.

**Table 4.** Call characteristics of *Cophixalus caverniphilus* sp. n. recorded from caves at Mt. Paramo, Muller Range, 1720 m, Southern Highlands Province, Papua New Guinea. BPBM 33747 was recorded at 0930 h, 4 April 2009; BPBM 33748 at 0855 h, 5 April 2009. Air (cave) temperatures were 17.8 and 17.6 °C, respectively.

Specimen	Call	Total notes	Call duration (s)	Notes/s	Mean note duration (s)	Mean internote duration (s)	Dominant frequency (Hz)
BPBM 33747	A	5	INTERFERENCE				2570
“	B	7	INTERFERENCE				2570
“	C	6	1.52	5.65	0.1721	0.0980	2530
“	D	7	1.81	6.06	0.1675	0.1055	2570
“	E	7	1.88	6.53	0.1699	0.1148	2570
“	F	8	2.06	6.84	0.1553	0.1196	2570
“	G	7	1.76	6.56	0.1556	0.1114	2570
“	H	8	2.14	6.28	0.1776	0.1031	2570
“	I	7	1.81	6.51	0.1625	0.1118	2530
“	J	8	1.98	7.24	0.1463	0.1157	2530
BPBM 33748	A	6	1.45	5.71	0.1597	0.0984	2530
“	B	7	1.74	6.22	0.1680	0.0938	2480
“	C	7	1.63	7.41	0.1373	0.1114	2480
“	D	6	1.50	6.09	0.1723	0.0922	2430
“	E	7	1.59	7.11	0.1539	0.0853	2430
“	F	7	1.66	6.96	0.1471	0.1043	2480
“	G	8	1.78	7.57	0.1376	0.0966	2480
“	H	9	2.18	6.60	0.1636	0.0890	2430



**Figure 5. A** Waveform, **B** power spectrum, and **C** spectrogram of the complete call of call “H” (Table 4) of *Cophixalus caverniphilus* sp. n. (BPBM 33748) recorded from a cave at Mt. Paramo, Muller Range, 1720 m, Southern Highlands Province, Papua New Guinea at 0830 h, 5 April 2009. Air (cave) temperature 17.6 °C.



**Figure 6. A** Waveforms of the first four notes of the call of *Cophixalus caverniphilus* sp. n. Call “J” of BPBM 33747 **B** Call “D” produced by BPBM 33748. See Table 4 for details.

Mean interval between notes was 0.1033 s (range 0.0380–0.1360) with no obvious tendency for the interval to lengthen or shorten over the course of the call. Notes are finely tuned, with a mean dominant frequency of 2510 Hz (range 2430–2570) (Fig. 5B), only weakly developed harmonic structure, and little or no change in note frequency over the duration of the call (Fig. 5C).

**Etymology.** The name is a masculine latinized compound adjective formed from the Latin “caverna”, meaning “cave” or “grotto”, and the Greek “philia”, meaning “fondness”.

**Range.** Known only from the vicinity of the type locality on the northeastern slopes of the Muller Range, Southern Highlands Province, Papua New Guinea (Fig. 4).

**Ecological notes.** Animals inhabit primary and secondary rainforest but were also common around largely cleared village areas. We found only one animal in primary rainforest, but they were common in highly disturbed areas around villages. In the latter areas, animals were abundant inside caves comprised of a hard, slick clay surface, but they were also common in grassy and lightly treed areas outside of caves. Within caves they could be found active on or calling from both horizontal and vertical surfaces or within horizontal or vertical cracks during the day. They were not limited to the mouths of the caves but were found well back into the caves in areas having little, if any, light.

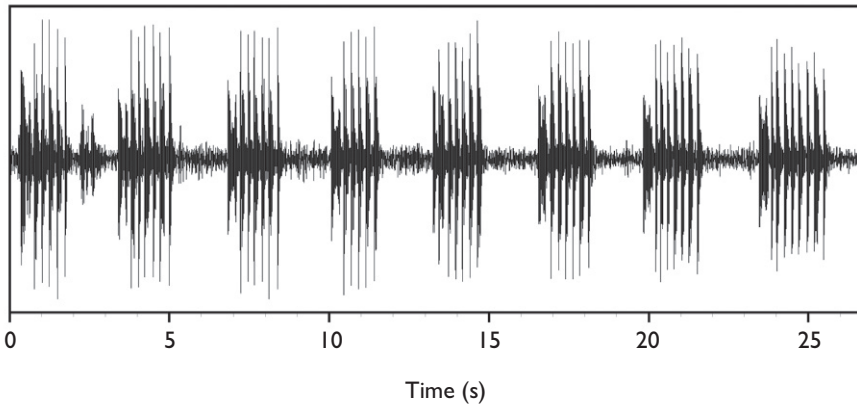
In the caves, calling occurred in waves, with silence predominating, but then followed by a one- or two-minute spate of calling. Some animals were calling from deep, inaccessible fissures at least 20 m from the mouth of the cave. During our observations, calling in caves occurred during the morning (until at least 0900 h); however, it is possible the frogs call throughout the day in such circumstances. Outside of caves, calling occurred primarily on wet mornings following night-time rain, with calling beginning at approximately 0500 h, diminishing after daylight (~0600 h), but continuing until at least 0930 h. One animal found calling during this time was perched approximately 1 m above the ground on *Dicranopteris linearis*. We never heard these frogs calling in the evening or night-time until the hour before dawn.

Syntopic microhylids include *Albericus darlingtoni*, *A. murritus*, *Callulops wilhelmanus*, *Choerophryne burtoni*, *Hylophorbus richardsi*, *Oreophryne notata*, *Xenorhina parkerorum*, and the species described below.

When disturbed, this frog plays dead, often lying on its back and refusing to move. However, unlike *Albericus darlingtoni*, they do not roll into a tight ball, but lie limply. One of us (FK) initially thought several animals in a collection bag were dead because of this habit, but they become active once righted and left undisturbed for a few moments.

**Remarks.** A distinctive aspect of the vocalization of this species is that it delivers a series of 8–10 calls at frequent, regular intervals (every 1.6 s for BPBM 33747 and every 2.3 s for BPBM 33748) (Fig. 7), with each series punctuated by a short period of silence of approximately the same duration. Other species of New Guinean *Cophixalus* that produce multi-note calls generally deliver them at irregular, much lengthier intervals. For example, the upper montane species, *Cophixalus sphagnicola* Zweifel and Allison, which has a call of 15–27 peeps, generally calls every 30–60 s (Zweifel and Allison 1982).





**Figure 7.** Wave form of all eight calls **A–H** recorded from *Cophixalus caverniphilus* sp. n. (BPBM 33748). See Table 4 for details.

This same behavior is seen in four recently described species of *Cophixalus* (Kraus and Allison, 2009). The holotype of *Cophixalus kethuk* (BPBM 20203) from Rossel Island in Milne Bay Province produced a call of 12–13 notes that sounded similar to “a marble falling and quickly coming to rest on a hard surface” (Kraus and Allison 2009). It called on average every 13 s (range 9–18 s,  $n = 5$ ). *Cophixalus phaeobalius*, from 1520 m in the Bowutu Mts in Morobe Province, produces a call of 4–7 peeps. We recorded a paratype (BPBM 26194) that called at fairly regular intervals of 32–43 s (mean 37,  $n = 4$ ). A morphologically similar species, *C. tomaiodactylus*, has a call consisting of 2–13 rapid peeps. Two paratypes (BPBM 23720, 26183) from middle to high elevations in the Bowutu Mts called irregularly every 23–74 s (mean 48,  $n = 27$ ). A third species from the Bowutu Mts, *C. linnaeus*, produces a long call consisting of 21–48 peeps. Calling frequency of the holotype (BPBM 31836) and two paratypes (BPBM 31337–38) ranged from 87–595 s (mean 186,  $n = 16$ ).

***Oreophryne anamiatoi* sp. n.**

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Fig. 1C, D

**Holotype.** BPBM 33768 (field tag FK 12882), collected by F. Kraus and J. Anamiato, E slope Mt. Itukua, Muller Range, 5.66954° S, 142.62334° E, 2177 m, Southern Highlands Province, Papua New Guinea, 27 March 2009.

**Paratypes (n = 20).** BPBM 33763, same data as holotype except collected 17 March; BPBM 33764, same data as holotype except collected 22 March; PNGNM 24097, same data as holotype except collected 25 March; BPBM 33765–66, same data as holotype except collected 26 March; BPBM 33767, same data as holotype; BPBM

33769–71, same data as holotype except collected 28 March; PNGNM 24098, same data as holotype except collected 29 March; BPBM 33772, same data as holotype except collected 30 March; PNGNM 24099, same data as holotype except collected 31 March; BPBM 33773–79, PNGNM 24100, Mt. Paramo, Muller Range, 5.64509° S, 142.63618° E, 1874 m, 3 April 2009.

**Diagnosis.** A medium-sized species of *Oreophryne* (adult SV = 23.4–29.7 mm) distinguished by its combination of a cartilaginous connection of the procoracoid to the scapula, no webbing between the toes, fifth toe longer than the third, relatively short snout (EN/SV = 0.073–0.086), dark face, venter with a dense array of dark-brown flecks, and call consisting of an extended multi-note chuckle or cackle.

**Comparisons with other species.** The new species differs from all Papuan congeners except *O. alticola* Zweifel, Cogger, and Richards, *O. asplenicola* Günther, *O. brevicrus* Zweifel, *O. clamata* Günther, *O. crucifera* (van Kampen), *O. flava* Parker, *O. habbemensis* Zweifel, Cogger, and Richards, *O. idenburgensis* Zweifel, *O. kampeni* Parker, *O. notata*, *O. pseudasplenicola* Günther, and *O. waira* Günther in having (vs. lacking) a procoracoid that reaches the scapula. It differs from *O. crucifera*, *O. idenburgensis*, *O. kampeni*, and *O. waira* in lacking (vs. having) webbing between the toes; and it differs from *O. alticola*, *O. brevicrus*, *O. clamata*, and *O. habbemensis* in having the fifth toe longer than (vs. shorter than or subequal to) the third. *Oreophryne anamiatoi* differs from the remaining species *O. asplenicola*, *O. flava*, *O. notata*, and *O. pseudasplenicola* in its larger size (23.4–29.7 mm vs. maximum of 21 mm in those four species) in having a uniformly dark face, and in its call (call a series of peeps in the other species, but call unknown in *O. flava*); it further differs from *O. asplenicola* and *O. pseudasplenicola* in its shorter snout (EN/SV > 0.086 in those species), from *O. notata* and *O. pseudasplenicola* in lacking (vs. having) an inverted white U on the face, and from *O. flava* in having an abdomen with dark-brown flecking (vs. immaculate yellow-white), and lacking (vs. having) a dark W-shaped mark between the shoulders.

**Description of holotype.** Adult female with incision on right side. Head wide (HW/SV = 0.40), with steep, slightly concave loreal region. Canthus rostralis rounded, concave when viewed from above. Nostrils directed laterally, closer to tip of snout than to eyes. Internarial distance broader than distance from naris to eye (EN/IN = 0.80, IN/SV = 0.101, EN/SV = 0.081). Snout truncate when viewed from the side, shallowly angulate when viewed from above. Eyes moderately large (EY/SV = 0.11); eyelid approximately two-thirds width of interorbital distance. Tympanum distinct but small (TY/SV = 0.047). Dorsal skin granular with series of weakly raised parallel ridges and scattered small pustules; ventral surfaces coarsely granular. Supratympanic fold narrow. Fingers unwebbed, bearing discs with terminal grooves; relative lengths 3>4>2>1. Finger discs approximately 3 times widths of penultimate phalanges, except for first finger, which is approximately twice width of penultimate phalanx. Subarticular tubercles well developed; inner metacarpal tubercle oval and low; outer rounded and obscure. Toes unwebbed, bearing discs with terminal grooves; relative lengths 4>5>3>2>1. Toe discs smaller than those of fingers (3<sup>rd</sup>F/4<sup>th</sup>T = 1.37), approximately twice width of penultimate phalanges. Subarticular tubercles low but

distinct; inner metatarsal tubercle large, oval; outer absent. Hind legs of moderate length (TL/SV = 0.46).

In preservative, dorsum medium brown with small black flecks scattered throughout, these concentrated dorsolaterally, mid-dorsally, and on top of head. Entire face to posterior of jaw angle uniform dark brown. Dark-brown postocular stripe extends along ventral side of supratympanic ridge. Rear and front of thighs uniform medium brown. Tops of wrist, hand, and first three fingers boldly marked with dark brown. Sides darker brown with very pale straw flecks. Venter very pale straw with bold, large, dark-brown flecks, these dense on chin, throat, and under legs, sparse on abdomen. Palmar and plantar surfaces dark brown spotted with very pale straw. Iris dark brown minutely flecked with silver.

**Variation.** Mensural variation for the type series is shown in Table 5. Sexual dimorphism is slight except that females clearly attain larger size than males and may have slightly narrower snouts (reflected in EN/IN values).

Dorsal ground color varies from light brown to dark brown, and pattern varies from virtually absent to moderately well stippled and streaked with black. Black stippling may be uniformly distributed, or concentrated laterally or dorsolaterally. Two specimens have a narrow tan vertebral stripe margined with black stippling. The dark face and postocular bar are present in all. Venters of all specimens are boldly spotted with dark brown on white, but two specimens have the abdomen clear and a few others have it less spotted than the chin and throat.

**Color in life.** BPBM 33764 (Fig. 1C): “Dorsum medium brown with a slight russet cast. Face dark brown; short dark-brown postocular dash; and few dark-brown lateral flecks. Rear of thighs brown, slightly darker than dorsum. Venter pale yellow heavily flecked with dark gray. Iris bronze with narrow red rim around pupil. Upper

**Table 5.** Mensural data for type series of *Oreophryne anamiatoi* sp. n. Data include only adult animals.

Character	Males (n = 11)		Females (n = 4)	
	mean	range	Mean	range
SV (mm)	25.2	23.4–26.7	29.0	27.4–29.7
TL/SV	0.45	0.43–0.49	0.47	0.45–0.48
EN/SV	0.077	0.073–0.082	0.079	0.075–0.084
IN/SV	0.103	0.100–0.107	0.100	0.098–0.102
SN/SV	0.14	0.13–0.15	0.13	0.13–0.14
TY/SV	0.045	0.039–0.056	0.049	0.047–0.051
EY/SV	0.12	0.11–0.13	0.12	0.11–0.12
HW/SV	0.39	0.38–0.40	0.39	0.38–0.40
HL/SV	0.33	0.32–0.35	0.33	0.32–0.34
3rdF/SV	0.071	0.062–0.083	0.074	0.065–0.082
4thT/SV	0.056	0.050–0.062	0.058	0.055–0.062
EN/IN	0.74	0.72–0.77	0.79	0.75–0.86
3rd F/4th T	1.28	1.20–1.40	1.27	1.18–1.37
HL/HW	0.85	0.81–0.89	0.85	0.82–0.86

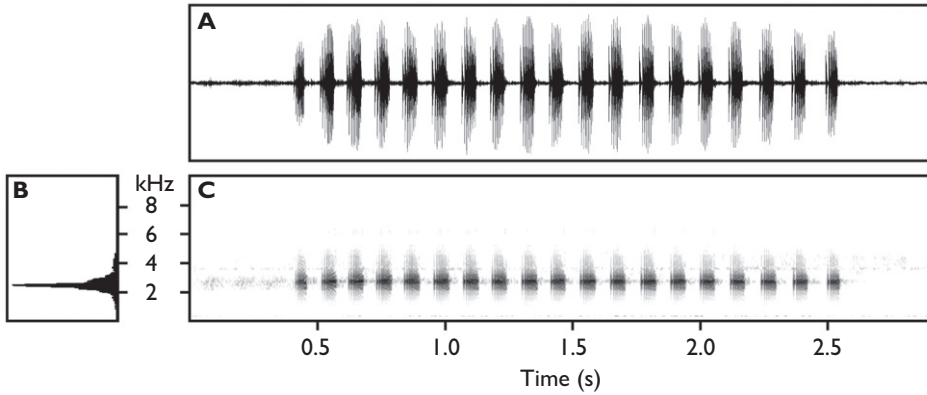
arms and tarsi burnt orange.” BPBM 33765 was uniform brown dorsally with a dark face mask and postocular stripe (Fig. 1D); rear and front of thighs, and groin, uniform brown, slightly darker than dorsum; venter dirty cream flecked with gray; iris dark brown. BPBM 33766 had black flecks on sides and venter brighter yellow but with fewer gray flecks and with white chromatophores; BPBM 33767 had the dorsum and rear of thighs burnt orange and venter pale yellow; BPBM 33769 and 33771 had a tan vertebral line. BPBM 33774 had a metallic green sheen on eyelids and top of snout; BPBM 33776 same but less extensive. PNGNM 24097 was light brown with straw yellow on sides, with dark-brown spots dorsally and laterally, denser on sides; face to rictus and short postocular stripe dark brown; rear of thighs brown like dorsum but unspotted; venter pale yellow spotted with dark-gray flecks; iris brown.

**Call.** Animals called during the first few hours of darkness. We recorded ten calls from two individuals (Table 6). The calls from both were similar, so we combined data from both for analysis.

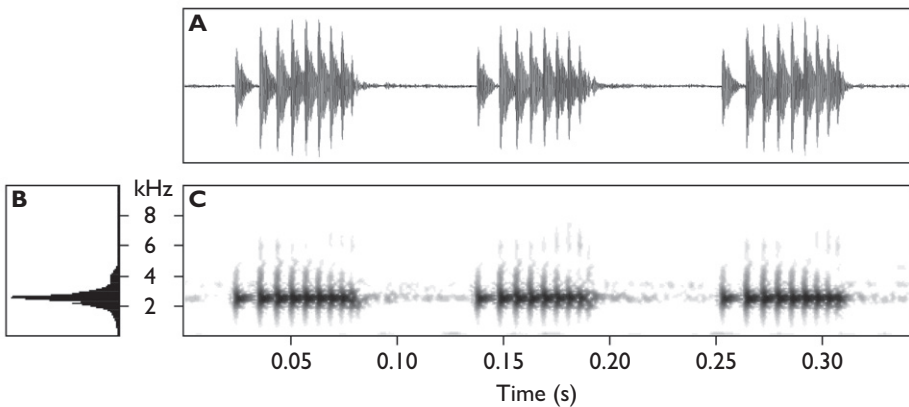
The call consists of 17–22 pulsed notes (Figs. 8A, 9A). Note duration was similar over the course of the call and averaged 0.0569 s (range 0.0266–0.0681). Inter-note intervals were also similar throughout the call and were similar in duration to the notes, averaging 0.0563 s (range 0.0390–0.0942). Mean call duration was 2.10s (range 1.77–2.33), and notes were delivered at a mean repetition rate of 18.5 notes/s (range 17.3–20.3). Number of pulses/note ranged from 3–11 (Fig. 9A), with a strong tendency to decrease over the course of the call (Fig 10). Modal number of pulses in the first three notes in each call ranged from 10–11, producing a mean rate for those notes of 200.9 pulses/s, while modal number of pulses in the last three notes ranged from 7–9, producing a mean rate for those notes of 146.4 pulses/s (Table 7). Notes are finely tuned, with a mean dominant frequency of 2490

**Table 6.** Call statistics of *Oreophryne anamiatoi* sp. n. recorded on Mt. Paramo, Muller Range, Southern Highlands Province, Papua New Guinea on 3 April 2009. BPBM 33774 was recorded at 2000 h and BPBM 33775 at 2100 h. Air temperatures were 17.0 and 17.7 °C, respectively.

Specimen	Call	Total notes	Call duration (s)	Notes/s	Mean note duration (s)	Mean internote duration (s)	No. pulses per note	Dominant frequency (Hz)
BPBM 33774	A	19	2.15	17.27	0.0611	0.0551	8–11	2540
“	B	20	2.33	17.86	0.0596	0.0598	8–12	2520
“	C	19	2.14	17.67	0.0596	0.0560	7–11	2520
“	D	19	2.13	18.12	0.0580	0.0569	7–11	2480
“	E	16	1.77	17.75	0.0572	0.0574	4–12	2480
“	F	18	1.96	18.68	0.0564	0.0553	3–11	2480
“	G	17	1.94	17.85	0.0584	0.0592	8–12	2460
BPBM 33775	A	22	2.31	20.29	0.0516	0.0558	6–12	2460
“	B	21	2.21	19.86	0.0532	0.0545	7–10	2460
“	C	20	2.08	19.80	0.0531	0.0536	7–11	2460



**Figure 8.** **A** Waveform, **B** power spectrum, and **C** spectrogram of Call “D” of *Oreophryne anamiatoi* sp. n. (BPBM 33774) recorded at Mt. Paramo, Muller Range, Southern Highlands Province, Papua New Guinea on 3 April 2009 at 2000 h. Air temperature 17.7 °C.



**Figure 9.** Detail of the middle three notes of call “D” of *Oreophryne anamiatoi* sp. n. (BPBM 33774). **A** Waveform, **B** power spectrum, and **C** spectrogram. Note the pulsing of the notes.

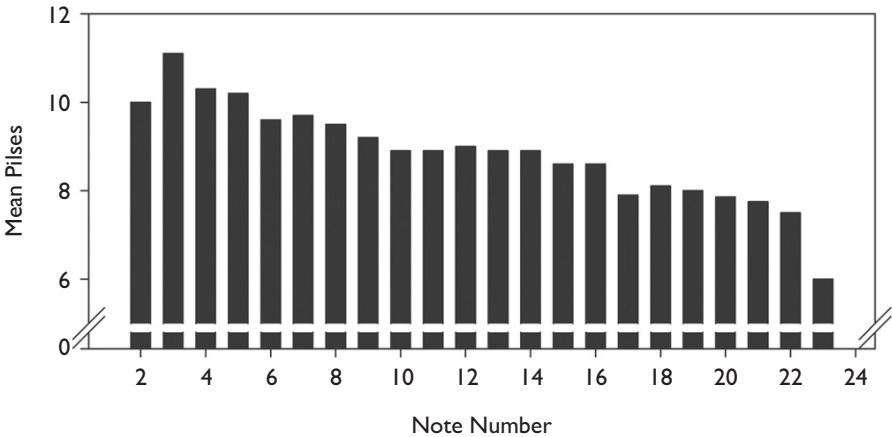
Hz (range 2460–2540) (Fig. 8B–C, 9B–C) and no frequency modulation over the duration of the note.

**Etymology.** The species is named for Jim Anamiato of the Papua New Guinea National Museum for his considerable assistance on several of our expeditions, including the one during which this frog was discovered.

**Range.** Known only from the vicinity of the type locality on the northeastern slopes of the Muller Range, Southern Highlands Province, Papua New Guinea (Fig. 4).

**Ecological notes.** Animals inhabited both primary and secondary rainforest at elevations ranging from 1870–2180 m. Most animals were found in the immediate vicinity of stream banks, but a few were found several meters away in adjacent forest. Males called from dense moss mats on standing or fallen trees from 1–5 m above the ground,





**Figure 10.** Number of pulses/note of *Oreophryne anamiattoi* sp. n. recorded at Mt. Paramo, Muller Range, Southern Highlands Province, Papua New Guinea on 3 April 2009. BPBM 33774 was recorded at 2000 h and BPBM 33775 at 2100 h. Air temperatures were 17.0 and 17.7 °C, respectively. See Table 7 for additional details.

**Table 7.** Pulse rates of the calls of *Oreophryne anamiattoi* sp. n. See Table 6 for additional details.

Specimen	Call	Pulses/s	
		First Three Notes	Last Three Notes
BPBM 33774	A	166.5	139.7
"	B	206.5	145.1
"	C	181.3	135.7
"	D	197.2	139.3
"	E	195.6	154.1
"	F	216.0	155.2
"	G	202.1	154.7
BPBM 33775	A	245.9	154.9
"	B	195.5	138.3
"	C	202.4	146.6

but several animals were found perched silently on low (<2 m above ground) vegetation, on *Pandanus* roots or near *Pandanus* trees. Syntopic microhylids include *Albericus darlingtoni*, *A. murritus*, *Callulops wilhelmanus*, *Choerophryne burtoni*, *Cophixalus caverniphilus*, *Hylophorbus richardsi*, *Oreophryne notata*, and *Xenorhina parkerorum*.

**Remarks.** Several species of *Oreophryne* give loud, rattling calls similar to that of *O. anamiattoi*. These include *Oreophryne clamata*, which gives a call of 10–23 pulsed notes (Günther 2003a); *O. kapisa* Günther, which produces 26–47 pulsed notes (Günther 2003b); and *O. waira*, which produces 6–11 pulsed notes (Günther 2003b).

The call of *Oreophryne anamiatoi* is most similar to that of *O. clamata* but differs from that species in having a slightly longer duration (1.77–2.33 s vs. 0.58–1.41s), a longer mean note duration (57 ms vs. 21 ms), a longer mean internote duration (56 ms vs. 39 ms), and a slightly lower dominant frequency (2460–2540 Hz vs. 2700–3600 Hz). Internote duration is fairly constant in *O. anamiatoi* but tends to lengthen over the course of the call in *O. clamata* (Günther 2003a).

## Discussion

With the addition of the three species described herein and other species recently collected by us, there are now at least nine species of microhylid frogs known from the Muller Range. These include four species that are endemic to but relatively widespread in the central highlands of Papua New Guinea (*Albericus darlingtoni*, *Callulops wilhelmanus*, *Oreophryne notata*, *Xenorhina parkerorum*) and two species (*Choerophryne burtoni*, *Hylophorbus richardsi*) that were recently described from uplands approximately 90 km and 60 km, respectively, to the southeast of the Muller Range. In addition, Smith (1980) listed *Cophixalus cryptotympanum* from the Muller Range. This taxon was originally described from Mt. Dayman on the Southeast Peninsula of Papua New Guinea and has been recorded from numerous montane localities throughout much of Papua New Guinea (Menzies 2006). However, the taxonomic status of this species is uncertain, and it is likely that it is a species complex, with the named form known with certainty only from Mt. Dayman. Hence, the record of *C. cryptotympanum* from the Mullers is best treated with caution at present.

A similar distributional pattern characterizes the hylid frogs that we found in the Muller Range. We obtained *Litoria angiana* (Boulenger), *L. arfakiana* (Peters and Doria), *L. darlingtoni* (Loveridge), *L. iris* (Tyler), *L. kumae* Menzies and Tyler, *L. micromembrana* (Tyler), and *L. modica* (Tyler). All of these except *L. kumae* are widespread montane species across Papua New Guinea (*Litoria angiana*, *L. arfakiana*, *L. micromembrana*, *L. modica*), or widespread within the central highlands (*L. darlingtoni*, *L. iris*). Only *L. kumae* is endemic to a small portion of the central highlands, being previously known from the vicinity of Tari, 35 km southeast of our collection site, and a couple of points a short distance south of Tari but still in Southern Highlands Province.

These rather limited details suggest that the frog fauna of the Muller Range is broadly representative of that of the central highlands but with a significant endemic element that appears to be restricted to uplifted limestone regions and adjacent volcanoes of the Southern Highlands. Additional endemic species may be expected in the subalpine and alpine regions (>3000 m) of the Muller Range.

## Acknowledgements

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## Appendix

### Additional specimens examined

- Albericus exclamitans*: Papua New Guinea: Morobe Province: along Dunch River, NW slope Mt. Shungol, 750–780 m (BPBM 18319, holotype; BPBM 18317–18, 18320–40).
- Albericus swanhildae*: Papua New Guinea: Southern Highlands Province: 16 km NE Mendi, 2400–2500 m (UPNG 5572, holotype; UPNG 5573–74, 5576, 5591–92, paratypes).



*Oreophryne idenburgensis*: Indonesia: Irian Jaya: Idenburg River, 18 km SW Bernhard Camp, 2150 m (AMNH 49663, holotype; AMNH 49666, paratype).

*Oreophryne kampeni*: Papua New Guinea: Central Province: Moroka (BMNH 1947.2.12.14, holotype; BMNH 1947.2.12.43–44, paratypes).

*Oreophryne notata*: Papua New Guinea: Southern Highlands Province: E slope Mt. Itukua, Muller Range, 2170 m (BPBM 33672–706).